

Device SEE Susceptibility Update: 1996-1998
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Abstract

This eighth Compendium continues the previous work of Nichols, et al, on single event effects (SEE) first published in 1985. Because the Compendium has grown so voluminous, this update only presents data not published in previous compendia.

I. Introduction

SEE test programs have continued for several years at the Jet Propulsion Laboratory (JPL), Aerospace Corporation, (ARSP) Goddard Space Flight Center (GSFC), and the European and French Space Agencies (ESA and CNES) to assess device susceptibility to heavy ion and/or proton environments. More recently, organizations such as Space Electronics, Inc (SEI), Matra-Marconi Space (MMS) and Saab have been making significant contributions in this research area. Seven compendia have been published by JPL since 1985 in the IEEE Transactions on Nuclear Science [1, 2, 3, 4] and the Radiation Effects Data Workshop Records [5, 6, 7].

Other testing compendia have been presented by other experimenters [e.g. 8, 9, 10]. However, these compendia have usually contained only that data produced by the test organization.

II. Testing Approaches

The testing approaches used by all these organizations, while similar, are not identical. Additionally, all these techniques are constantly evolving and moving more and more to computer-control. In general, the testing procedures follow those outlined in the ASTM F1.11 or JEDEC 13.4 documents [11, 12] on single event testing.

III. Data Organization and Scope

This paper summarizes single event upset (SEU) and latchup (SEL) data from 1996 to 1998 from numerous sources. Some additional data from earlier years has come to light and is included, as well as a limited data set on proton displacement damage. Single event gate rupture (SEGR) or burnout (SEB) of power transistors is not included, but has previously been presented in the Radiation Effects Data Workshop Records [13, 14, 15]. There is also a limited set of published SEE data using neutrons [8, 16], but because of the paucity of data, this is not included here.

The data reported in the tables is substantially abbreviated, generally including only thresholds and saturation cross sections, and ignores any statistical features. The data has been excerpted directly from the referenced reports, but in some cases data is not shown because only reduced data was shown in the reference. In these instances, the reference is for completeness only, and the reader should contact the original author(s) for clarification. Because of different definitions of what constitutes threshold (no upsets, cross section at 10% of saturation, etc.), the user would be advised to review the original reference for the author's definition of "threshold". Although we have endeavored to provide the user with data source references, because of processing changes it is always advisable to consider a test on the actual flight lot, particularly if the Compendium shows that a device may be marginal for a given mission.

Previous Compendia versions presented predominantly heavy ion data, with a few entries on proton testing. Because of the significant amount of work performed in the past few years with proton accelerators, this

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data has been separated out into separate tables. Table 1 shows data from heavy ion testing while Tables 2 and 3 show proton data. The Compendium layout from previous years has also been somewhat modified to make it easier to use.

In addition to dividing heavy ion and proton data into separate tables, other significant changes were removal of latchup information from the remarks and placing it into separate columns, thus providing more comprehensive data sets. These changes allow the user to quickly scan a row and, where it exists, get both upset and latchup phenomena data.

IV. Heavy Ions

Because of the interest in using commercial-off-the-shelf (COTS) devices in space, the bulk of the work in recent years has concentrated on this class of parts. Designers are particularly interested in these devices because of their capabilities and speed, which are typically superior to most “rad-hard” devices. Foremost in most modern-day designs is the desire for massive amounts of data collection. To this end, much of the more recent testing has concentrated on high-density memories, FPGAs and 32-bit microprocessors.

The desire for reliability has also fostered a higher interest in SEL rather than SEU. Upsets can usually be ameliorated with proper software or hardware design [17], but a SEL failure can result in loss of an entire mission. It is recognized that SEL susceptibility may have a strong temperature dependence [18], but temperature data is often not presented in the original reference. Whenever temperature information is noted in the reference, this data is shown in the remarks column. Unless an elevated temperature is noted, the data is assumed to be taken at device ambient operating temperature, which may, or may not be, the same as room temperature.

V. Protons

As COTS devices get smaller and require less charge to initiate an upset, they are trending toward an increased sensitivity to protons that can be in the form of SEU, SEL, single event transients (SET) or displacement damage. Similarly, to testing done with heavy ions, much of the proton testing has been done with an eye toward handling massive amounts of data on the spacecraft.

Recent data has also shown that optical devices, such as some optocouplers and/or infrared LEDs, may be quite vulnerable to proton-induced upset, latchup or degradation. This is evidenced by the amount of optocoupler data in Table 2, as well as on-orbit SET data from the Hubble Space Telescope [19].

Other recent data has also shown that many optoelectronic and bipolar linear circuits may also be vulnerable to proton-induced displacement damage (Table 3). The vulnerability of optocouplers to degradation has been predicted and documented on the TOPEX-Poseidon spacecraft [20]. While not technically a SEE, this data has been included here for completeness.

VI. Conclusions

The latest available heavy ion and proton-induced SEE data on microcircuits has been gathered from multiple test laboratories and placed into general device categories. Data on proton displacement damage in selected device types is also presented. The data presented here, along with all previous data, can be found on JPL's World Wide Web site at radnet.jpl.nasa.gov.

VII. References

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TABLE 1
Heavy Ion SEE Testing - 1996 to 1998

Test Org.*	Device	Function	Technology	Mfr. SEU LET**	Effective Device Threshold	Bits Tested	Bit Xsection (μm²)	LU _{in}	Xsection (cm²)	Frac.	Remarks
GSFC	1840RP	Analog Switches/MUXs		SEI	>110			1997			BNL O'Bryan, et al. 98IEEE Workshop Record, pg. 39.
GSFC	65C02	16-channel analog MUX	ASICs	CMOS Fab 1	SEI	>21<27	1.5E-04	Feb-97			UCB Layton, et al. 98IEEE Workshop Record, pg. 170.
SEI	MP7684	ASIC process test	ASIC (6-bit)	CMOS	ADI	7	3.0E-04	Mar-97			BNL Label, et al. 98IEEE Workshop Record, pg. 14.
GSFC	ADM70	Successive Approximation	CMOS	ECL (Bipolar)	HAR			Mar-97	>70		BNL Temp. increased -32°C to 69°C during test.
JPL	HII1276	Flash		CMOS	EXR	<11.4	6.0E-02	1997	18 to 26.6		BNL Layton, et al. 98IEEE Workshop Record, pg. 170.
JPL	TMC1175CV20	Video Flash		Siemens CMOS	RAY			Jun-96	25	1.1E-04	BNL LU rate (CCR) = 5E-03/yr
ESA	AD7193SQ	Serial 5.5 μs conversion time	LC-MOS	ADI	14	-2.5E-05		1997	>68		CYC Bee, et al. 98IEEE Workshop Record, pg. 58.
GSFC	CS5012	Self-check, parallel serial interface	CMOS	CRY	3.5 to 4.8			Mar-97	11		Label, EEE Links, Vol. 3, No. 1, Mar 97
JPL	AD9240	ADC (12-bit)	ADC (14-bit)	CMOS	ADI			1997	25	6.0E-04	TAM Miyahira, preliminary IPL internal report.
JPL	AD9243	10 MSPS Binary parallel out	CMOS	ADI				1997	25	6.0E-04	TAM Miyahira, preliminary IPL internal report.
JPL	ADS-946-2	3 MSPS Binary parallel out	CMOS	DAT				1997	7.7	4.0E-06	TAM Miyahira, preliminary IPL internal report.
GSFC	7805LRP	ADC (16-bit)	ADC (16-bit)	CMOS	SEI	<1.45		1997	-11.4		BNL O'Bryan, et al. 98IEEE Workshop Record, pg. 39. LU protection circuit test - OK.
SEI	7809LRP	100 KSPS, 100mW max. power dissipation. Parallel output	CMOS	BUB	18	5.0E-05		Mar-97	19.9	3.0E-05	BNL Layton, et al. 98IEEE Workshop Record, pg. 170.
ESA	AD676AD	100 KSPS, 100mW max. power dissipation. Serial output	CMOS	ADI	-1.8	>5.0E-05		1997	>28		CYC Bee, et al. 98IEEE Workshop Record, pg. 58. Transient and latching errors recorded.
BALL	AD677	Parallel successive approx., 10 μs conv. time.	Hybrid BiMOS II	ADI	3.4			Dec-94			
ESA	AD7188AQ	100 KSPS, Serial output	Hybrid CMOS & BiMOS II	ADI	-2	2.5E-03		1997	>68		CYC Bee, et al. 98IEEE Workshop Record, pg. 58.
GSFC	AD976	Two pass flash, 5.3 s conversion time	LC-MOS	ADI	<3.8			1997	>80		BNL O'Bryan, et al. 98IEEE Workshop Record, pg. 39. DIC 9723.
JPL	AD9260	parallel, internal 2.5 V ref.	BiCMOS	ADI				1997	7.7	2.0E-05	TAM Device failed after second latchup.
SEI	AD57809	Parallel, sigma-delta	CMOS	BUB	17.8	9.0E-05		Mar-97	19.4	3.0E-05	BNL Layton, et al. 98IEEE Workshop Record, pg. 170. DIC 7550 & 9649.
JPL	AD5-937	100 KSPS, 100mW max. power dissipation. Serial output	CMOS (hybrid)	DAT				1997	7.7	2.0E-04	TAM Miyahira, preliminary IPL internal report. All upsets from gate array chip.
JPL	AD7714-3	Parallel output, low power.	CMOS (hybrid)	ADI				Jun-97	55	2.0E-05	BNL LU rate (CCR) = 1.5E-04/yr.
GSFC	DAC8800	DAC (8-bit)	OCAL, serial input	Bipolar	ADI	>80		Mar-97	>80		Label, EEE Links.
GSFC	MX78477Q	DAC (12-bit)	Dual, parallel input	CMOS	MXM	-10		1997	>75		BNL O'Bryan, et al. 98IEEE Workshop Record, pg. 39. DIC 9715.

TABLE 1 (cont.)
Heavy Ion SEE Testing - 1996 to 1998

Test Org.*	Device	Function	Technology	Mfr.	Effective SEU LET* Threshold	Device Xsection [Tested] (cm ⁻²)	Bit Xsection (μm ²)	Test Date	L _U _{lh}	Xsection (cm ⁻²)	Fac.	Remarks	Date
DAC (18-bit)													1-Aug-99
GSFC S9380				SIP	1.45 to 14			1995	37 to 60		BNL	Label, et al., 96IEEE Workshop Record, pg 19. Catastrophic Latchup.	
GSFC 7804	DC/DC Power Converters		Hybrid	ADA	>37	<1.0E-07		1997			BNL	O'Bryan, et al., 98IEEE Workshop Record, pg 39.	
GSFC 5690R-D15	Dual output, +15 V	Hybrid	MDI	26.6				1996			BNL	Label, et al., 97IEEE Workshop Record, pg 14. SEB/SEG/R @ LET = 30.7. Destructive condition @ LET = 52.6.	
GSFC AHF2812	Single output, 12 V	Hybrid	ADA	>37 (drop-outs)				1997			BNL	O'Bryan, et al., 98IEEE Workshop Record, pg 39. ~10 ms drop-outs @ LET = 26.6. Dropout times @ 50% >~83% loads.	
GSFC AS42805SCH	Single output, +5 V	Hybrid	ADA	>4.0E-05				1997			BNL	Data @ 1% load: <20% w/ 180 ohm internal resistor; 20% >~50% w/ 2 kohm internal resistor.	
GSFC ATW2805S	Single output, +5 V	Hybrid	ADA	>37 (drop-outs)				1997			BNL	O'Bryan, et al., 98IEEE Workshop Record, pg 39. ~10 ms drop-outs @ LET = 26.6. Dropout times @ 70% >~83% loads.	
GSFC ICL7662MTV-4	Voltage Converter		MMX	59.7					>80		BNL	Label, et al., 96IEEE Workshop Record, pg 19. SEB/SEG/R @ LET = 30.7.	
GSFC MCH2805S	Single output, +5 V	Hybrid	ITP	>100							BNL	Data @ V _{cc} = 15 V - higher V _{cc} shows no errors.	
GSFC MD12880	DC/DC Power Converter	Hybrid (proprietary mod)	MDI	30							BNL	Label, et al., 96IEEE Workshop Record, pg 19. No SEEs @ LET = 100.	
DSP (16-bit)													
ARSP SM1320C50GFAMS0	Fixed point - SARAM	CMOS, 0.7 μm feature, 6.5 μm epi.	TIX	3	1.0E-02			1997	>63		UCB	Train, et al., 98IEEE Workshop Record, pg 51. DIC 9711B. Lockup errors above LET = 15.	
ARSP SM1320C50GFAMS0	Fixed point - DARAM	CMOS, 0.7 μm feature, 6.5 μm epi.	TIX	3	3.0E-03			1997	>63		UCB	Train, et al., 98IEEE Workshop Record, pg 51. DIC 9711B. Lockup errors above LET = 15.	
ARSP SM1320C50GFAMS0	Fixed point - PLU, ALU	CMOS, 0.7 μm feature, 6.5 μm epi.	TIX	5	1.0E-03			1997	>63		UCB	Train, et al., 98IEEE Workshop Record, pg 51. DIC 9711B. Lockup errors above LET = 15.	
ARSP SM1320C50GFAMS0	Fixed point - NOP	CMOS, 0.7 μm feature, 6.5 μm epi.	TIX	5	2.0E-04			1997	>63		UCB	Train, et al., 98IEEE Workshop Record, pg 51. DIC 9711B. Lockup errors above LET = 15.	
DSP (32-bit)													
ESA ADSP-21020KG-133	FPU	CMOS	ADI	7	2.0E-03			1996	29	9.0E-04	BNL	Hanboe-Sorensen, et al., RADEC97 Data Workshop, pg 97. DIC 9623, Rev 3 etc.	
ESA ADSP-21020KG-120	FPU	CMOS	ADI	5	2.0E-03			1996	16.5	1.5E-02	BNL	Hanboe-Sorensen, et al., RADEC97 Data Workshop, pg 97. DIC 942621/1/9512, Rev 1.	
ESA ADSP-21020KG-80	FPU	CMOS	ADI	5	2.0E-03			1996	12	3.0E-02	BNL	Hanboe-Sorensen, et al., RADEC97 Data Workshop, pg 97. DIC 9211/9528, Rev 1.	
ARSP SM1320C30GB	NOP, Cache, ALU	CMOS (V.5.3), 6.5 μm epi, min 0.7 μm feature size.	TIX	3	2.0E-04			1997	>63		UCB	Train, et al., 98IEEE Workshop Record, pg 51. DIC 9543. Snapback also observed.	
ARSP SM1320C30GB	General Register	CMOS (V.5.3), 6.5 μm epi, min 0.7 μm feature size.	TIX	3	7.0E-04			1997	>63		UCB	Train, et al., 98IEEE Workshop Record, pg 51. DIC 9543. Snapback also observed.	
ARSP SM1320C40HFM-40	NOP	CMOS 30C-21.22, 6.5 μm epi, min 0.7 μm feature size.	TIX	5	1.0E-05			1997	>63		UCB	Train, et al., 98IEEE Workshop Record, pg 51. DIC 9546A. Snapback also observed.	
ARSP SM1320C40HFM-40	Cache	CMOS 50C-21.22, 6.5 μm epi, min 0.7 μm feature size.	TIX	3	3.0E-05			1997	>63		UCB	Train, et al., 98IEEE Workshop Record, pg 51. DIC 9546A. Snapback also observed.	
ARSP SM1320C40HFM-40	ALU	CMOS 50C-21.22, 6.5 μm epi, min 0.7 μm feature size.	TIX	5	2.0E-05			1997	>63		UCB	Train, et al., 98IEEE Workshop Record, pg 51. DIC 9546A. Snapback also observed.	
ARSP SM1320C40HFM-40	General Register	CMOS 50C-21.22, 6.5 μm epi, min 0.7 μm feature size.	TIX	5	7.0E-05			1997	>63		UCB	Train, et al., 98IEEE Workshop Record, pg 51. DIC 9546A. Snapback also observed.	
ARSP SM1320C40HFM-40	RAM	CMOS 50C-21.22, 6.5 μm epi, min 0.7 μm feature size.	TIX	5	2.0E-03			1997	>63		UCB	Train, et al., 98IEEE Workshop Record, pg 51. DIC 9546A. Snapback also observed.	
FIFOs													
GSFC 6704EV-50	4K x 9	CMOS	TEM	3					1997.		BNL	O'Bryan, et al., 98IEEE Workshop Record, pg 39. DIC 9436. LET _{th} ~ 3 (byte errors); ~ 8 control errors; ~ 35 (mode change).	
GSFC M6720EV-50	4K x 9	SCMOS/epi RT	TEM	37.1				1996	64.7		BNL	Label, et al., 97IEEE Workshop Record, pg 14.	

TABLE 1 (cont.)
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Test Org.*	Device	Function	Technology	Mfr.	Effective SEU LET**	Device Threshold	Bit Xsection (cm ²)	Bit Xsection (μm ²)	Test Date	LU _h	Xsection (cm ²)	Fac.	Remarks
FPGAs													
SEI 1000BL	50k Gate reprogrammable PLA	CMOS	GTF						Jan-97 Oct-97	7.7 to 12	3.0E-02	TAB	Layton, et al. 98IEEE Workshop Record, pg 170.
GSFC 3090A	9000 equiv. 2-input gates	CMOS	XIL	4 to 7					1996	4 to 7		BNL	Label, IEEE Links, Vol. 3, No. 1, pg 5, Mar 97 & 97IEEE Workshop Record pg 14. Bit errors.
SAAB A1280XL (5.0 V)	8000 equiv. 2-input gates	CMOS (0.6 μm).	ACT	10		2.5E-07		1997	>110			CYC	Matison, et al. SAAB Doc. SER/REP/0078/K, 10/97. DIC 9709. S-module errors.
SAAB A1280XL (5.0 V)	8000 equiv. 2-input gates	CMOS (0.6 μm).	ACT	10		2.0E-07		1997				CYC	Matison, et al. SAAB Doc. SER/REP/0078/K, 10/97. DIC 9709. I/O-module errors.
SAAB A1280XL (5.0 V)	8000 equiv. 2-input gates	CMOS (0.6 μm).	ACT	28		8.0E-07		1997				CYC	Matison, et al. SAAB Doc. SER/REP/0078/K, 10/97. DIC 9709. C-module errors.
SAAB A1280XL (3.3 V)	8000 equiv. 2-input gates	CMOS (0.6 μm).	ACT	5		3.5E-06		1997				CYC	Matison, et al. SAAB Doc. SER/REP/0078/K, 10/97. DIC 9709. S-module errors.
SAAB A1280XL (3.3 V)	8000 equiv. 2-input gates	CMOS (0.6 μm).	ACT	5		2.2E-06		1997				CYC	Matison, et al. SAAB Doc. SER/REP/0078/K, 10/97. DIC 9709. I/O-module errors.
SAAB A1280XL (3.3 V)	8000 equiv. 2-input gates	CMOS (0.6 μm).	ACT	20		2.0E-06		1997				CYC	Matison, et al. SAAB Doc. SER/REP/0078/K, 10/97. DIC 9709. C-module errors.
GSFC A14100A	10000 equiv. 2-input gates.	COS/epi?	ACT	8					1996			BNL	Label, et al. 97IEEE Workshop Record, pg 14. S- & I/O-module errors.
GSFC A14100A	10000 equiv. 2-input gates.	COS/epi?	ACT	21					1996			BNL	Label, et al. 97IEEE Workshop Record, pg 14. C-module errors.
GSFC A1460A	6000 equiv. 2-input gates	CMOS/epi (1.0 μm feature size)	ACT	6 to 8					1996			BNL	Label, et al. 97IEEE Workshop Record, pg 14. S- & I/O-module errors.
GSFC A1460A	6000 equiv. 2-input gates	CMOS/epi (1.0 μm feature size)	ACT	25 to 30					1996			BNL	Label, et al. 97IEEE Workshop Record, pg 14. C-module errors.
GSFC A2140DX	14000 gates	CMOS, 3200DX family	ACT						1997	>75		BNL	Katz, IEEE Links, Vol. 3, No. 3, pg 16, Sep 1997.
SAAB A2140DX (3.3 V)	14000 gates	CMOS, 3200DX family	ACT	5		3.0E-06		1996	>110			CYC	Matison, et al. SAAB Doc. SER/REP/0078/K, 10/97. DIC 9703. S-module errors.
SAAB A2140DX (3.3 V)	14000 gates	CMOS, 3200DX family	ACT	5		2.5E-06		1996	>110			CYC	Matison, et al. SAAB Doc. SER/REP/0078/K, 10/97. DIC 9703. I/O-module errors.
SAAB A2140DX (3.3 V)	14000 gates	CMOS, 3200DX family	ACT	15		2.0E-06		1996	>110			CYC	Matison, et al. SAAB Doc. SER/REP/0078/K, 10/97. DIC 9703. C-module errors.
SAAB A2140DX (5.0 V)	14000 gates	CMOS, 3200DX family	ACT	10		2.0E-06		1996	>110			CYC	Matison, et al. SAAB Doc. SER/REP/0078/K, 10/97. DIC 9703. S-module errors.
SAAB A2140DX (5.0 V)	14000 gates	CMOS, 3200DX family	ACT	2		2.0E-06		1996	>110			CYC	Matison, et al. SAAB Doc. SER/REP/0078/K, 10/97. DIC 9703. I/O-module errors.
SAAB A2140DX (5.0 V)	14000 gates	CMOS, 3200DX family	ACT	30		8.0E-07		1996	>110			CYC	Matison, et al. SAAB Doc. SER/REP/0078/K, 10/97. DIC 9703. C-module errors.
GSFC A3220DX	20000 gates	CMOS, 3200DX family	ACT						1997	11	1.5E-05	BNL	Katz, IEEE Links, Vol. 3, No. 3, pg 16, Sep 1997. No saturation @ LET = 52.
GSFC CLAy-31	3134 equiv. Gates	RAM-based GaAs.	NSC	5					>90			BNL	Label, et al. 97IEEE Workshop Record, pg 14. Data errors.
GSFC CLAy-31	3134 equiv. Gates	RAM-based GaAs.	NSC	11					>90			BNL	Label, et al. 97IEEE Workshop Record, pg 14. Reconfiguration/sapback errors.
GSFC K911		Rad-hard, 2 μm epi (3.0 V)	LMA	18.8	-1.5E-06				9E-97			BNL	Katz, IEEE Links, Vol. 3, No. 2, pg 24.
GSFC MP911		CMOS, 10 μm epi (3.3 V)	MAT	18.8	-1.5E-06				9E-97			BNL	Katz, IEEE Links, Vol. 3, No. 2, pg 24.
GSFC MP911		Bulk CMOS, 0.8 μm features.	YAM	~37	2.0E-06				Feb-97	>70		BNL	Katz, et al. IEEE Links, Vol. 3, No. 2, pg 21, Jun 1997.
GSFC QYH580LPGA	35000 gates (5.0 V)	Bulk CMOS, 0.8 μm features.	YAM	~37					Feb-97	-67	4.0E-05	BNL	I(U @ 60 with 5.5 V.

TABLE 1 (cont.)

Heavy Ion SEE Testing - 1996 to 1998

Test Org.*	Device	Function	Technology	Effective SEU LET**	Device Xsection	Bit Tested	Test Date	LU _{th}	LU	Remarks	
				Mfr.	(cm ²)	(μm ²)		(cm ²)	Xsection (cm ²)	Fac.	
SAAB	RH1280 (5.0 V)	8000 equiv. 2-input gates	CMOS/epi (rad-hard LMA, 0.8μm)	ACT	30	4.5E-07	1997	>110	CYC	Matson, et al. SAA/B Doc. SEREP/0078/K, 1097. DIC 9617. C-module errors.	
SAAB	RH1280 (5.0 V)	8000 equiv. 2-input gates	CMOS/epi (rad-hard LMA, 0.8μm)	ACT	10	1.5E-07	1997		CYC	Matson, et al. SAA/B Doc. SEREP/0078/K, 1097. DIC 9617. S- & I/O-module errors.	
SAAB	RH1280 (3.3 V)	8000 equiv. 2-input gates	CMOS/epi (rad-hard LMA, 0.8μm)	ACT	25	8.0E-07	1997		CYC	Matson, et al. SAA/B Doc. SEREP/0078/K, 1097. DIC 9617. C-module errors.	
SAAB	RH1280 (3.3 V)	8000 equiv. 2-input gates	CMOS/epi (rad-hard LMA, 0.8μm)	ACT	8	2.0E-06	1997		CYC	Matson, et al. SAA/B Doc. SEREP/0078/K, 1097. DIC 9617. S- & I/O-module errors.	
LMC	XC4316XL	16000 equiv. gates.	CMOS/7 μm epi, 0.35 mm (3.3 V).	XIL	<15		1997	>100	BNL	Lum, LMC Tech Memo TM26-98. Upsets mainly in "basement" (control) logic. Tested @ 125° C.	
SEI	IW303LPRP	50k Gate reprogrammable PLA	CMOS	HTC	11	3.7E-03		1997	>25	BNL	Layton, et al. 98IEEE Workshop Record, pg 170
SEI	22V10RFP	Reprogrammable PLA	CMOS	HTC	<11	7.5E-05		1997	>80	BNL	Layton, et al. 98IEEE Workshop Record, pg 170
SEI	22V10RP	PLA	CMOS	HTC	<3	4.5E-04		1997	>117	BNL	Layton, et al. 98IEEE Workshop Record, pg 170
GSFC	22V10RPF	PLA	CMOS	SEI	<3.38		1997	>72.9	BNL	O'Bryan, et al. 98IEEE Workshop Record, pg 39. DICs XC3490/8493, XC 3495/8484 and 0261/1202. FFE errors.	
GSFC	22V10RPF	PLA	CMOS	SEI	>10		1997	>72.9	BNL	O'Bryan, et al. 98IEEE Workshop Record, pg 39. DICs XC3490/8493, XC 3495/8484 and 0261/1202. Combinatorial errors.	
GSFC	HX2300	SOI Test, Metal	RICMOS SOI4	HON	>120		1995	>120	BNL	LaFelt, et al. 96IEEE Workshop Record, pg 19.	
GSFC	IMP50E10	Electrical Programmable Analog Circuit	CMOS	IMP	1.45		1997	15 to 26.6	BNL	LaFelt, et al. 96IEEE Workshop Record, pg 19.	
GSFC	SAB-BT245	Octal Transceiver	BICMOS	NSC	>100		1997	>100	BNL	O'Bryan, et al. 98IEEE Workshop Record, pg 39.	
GSFC	SAB-BT245	Octal Transceiver	BICMOS	PHL	>100		1997	>100	BNL	O'Bryan, et al. 98IEEE Workshop Record, pg 39.	
JPL	74LVQ244	Buffer/epi (3.3 V)	CMOS	NSC			Apr-96	>120	BNL		
GSFC	AM7968 & AM7969	TAXI Transmitter & Receiver	Bipolar	AMD	<3.4		1996	>53	BNL	GANTL required power reset.	
MMS	AM79C98	Twisted Pair Transceiver	CMOS	AMD	>42		1995	50	GANTL	Pooley, et al. 96IEEE Workshop Record, pg 73. DIC 9545. LU cross section @ LET=2.	
MMS	DPR392CV	Coaxial Transceiver Interface	Bipolar, low power Schotthy, junction isolated	NSC	-1	2.0E-13		1995	>60	GANTL	Pooley, et al. 96IEEE Workshop Record, pg 73. DIC 9545. Transmit mode. Errors GSI normalized/transmitted bit.
MMS	DPR392CV	Coaxial Transceiver Interface	Bipolar, low power Schotthy, junction isolated	NSC	-1	2.0E-14		1995	>60	GANTL	Pooley, et al. 96IEEE Workshop Record, pg 73. DIC 9545. Receive mode. Errors GSI normalized/transmitted bit.
JPL	LY244	Octal Buffer/Driver (3 V)	CMOS	PHL			Apr-96	>120	BNL	Tested @ 90° C.	
JPL	LYC245	Octal bidirectional buffer	CMOS	PHL			Apr-96	85	BNL	Latchup current > 50 mA.	
GSFC	MC4429AIB	Linear Driver		MIC	>84.7		1997	>84.7	BNL	O'Bryan, et al. 98IEEE Workshop Record, pg 14.	
GSFC	SN74ABT245AJ	Octal Buffer/Driver	CMOS	TX	>100		1997	>100	BNL	O'Bryan, et al. 98IEEE Workshop Record, pg 39.	
GSFC	UT63M147-BPC	1553 Transceiver	CMOS	UTM	11		1996	>35	BNL	LaFelt, et al. 98IEEE Workshop Record, pg 14.	
JPL	CD4014	Logic Devices		CMOS	HAR	>120	Apr-96			Tested @ 125° C. DIC 9493. Test of newer vintage CD4xxx family.	
NASDA	934149	SRAMs	Bipolar	FSC?						Shimano, et al. 91IEEE TNS, Vol. 38, No. 6, pg 1693	
NASDA	934149	512-bit									

TABLE 1 (cont.)
Heavy Ion SEE Testing - 1996 to 1998

Test Org.*	Device	Function	Technology	Mfr.	Effective SEU LET**	Device Xsection	Bit Xsection	Test Date	L Ub (cm ⁻²)	LUb (cm ⁻²)	Frac.	Remarks
GSFC	68128	128K x 8	CMOS (1.0 μ m) w/NMOS periph.	HTC	1.45			1995	>60		BNL	Label, et al. 96IEEE Workshop Record, pg 19. Address errors.
GSFC	68128	128K x 8	CMOS (1.0 μ m) w/NMOS periph.	HTC	3.38			1995	>60		BNL	Label, et al. 96IEEE Workshop Record, pg 19. Bit errors.
GSFC	68128	128K x 8	CMOS (1.0 μ m) w/NMOS periph.	HTC				1995	>60		BNL	Label, et al. 96IEEE Workshop Record, pg 19. Address errors.
NASDA	pP4464D-20	2K x 8	CMOS	NEC				1997	4.56	2.4E-01	var.	Goka, et al. 98IEEE TNS, No. 6, pg 2771.
SEI	32C408	512K x 8	CMOS	SEI	3.3	3.5E-05		1997	>117		BNL	Layton, et al. 98IEEE Workshop Record, pg 170.
NASDA	3651W1910XCR	64K	CMOS/epi	NEC	16.6	6.4E-02	1.0E-06	1997	>70		TIARA	Goka, et al. 98IEEE TNS, No. 6, pg 2771.
NASDA	3651W9200XB	256K	CMOS	HTC	7.2	5.1E-02	2.0E-07	1997	>62		var.	Goka, et al. 98IEEE TNS, No. 6, pg 2771.
GSFC	5C10RFE-M	128K x 8	CMOS	AUS	<3.38	2.0E-01		1997	>50		BNL	O'Bryan, et al. 98IEEE Workshop Record, pg 39. Multi-bit errors also seen.
MMS	ASSCAR/RGW-35E	512K x 8	CMOS/epi, 0.5 μ m feature size	MOT	-1			8.1E-07			CYC	Pooley, et al. 98IEEE Workshop Record, pg 68. DiC 9731. MOT chips packaged by Austin.
GSFC	ASSCS12K8	512K x 8	CMOS	AUS	<3.38	1.0E-03		1997			BNL	O'Bryan, et al. 98IEEE Workshop Record, pg 39. Multi-bit errors also seen.
MMS	CX2K511000BP-10LL	128K x 8	CMOS	SNY	-2			1.0E-08	1997	>68	CYC	Pooley, et al. 98IEEE Workshop Record, pg 68.
ESA	E54	4M x 4	CMOS	IBM	-1			5.0E-09	1997		PSI	Hartoe-Sorensen, et al. 98IEEE Workshop Record, pg 74.
MMS	HMA02128BLP-7	128K x 8	HICMOS, 0.8 μ m features, Rev B.	HTC	-2			3.0E-07	1997		CYC	Pooley, et al. 98IEEE Workshop Record, pg 68. DiC 9713
MMS	HMC28512ALP-7	512K x 8	HICMOS, 0.5 μ m features, Rev B.	HTC	-2			2.0E-07	1997		CYC	Pooley, et al. 98IEEE Workshop Record, pg 68. DiC 9705
SNL	HMS5556	32K x 8	CMOS, 0.8 μ m, rad-tolerant	TEM	-1	1.5E-01		1997			BNL	Dodd, et al. 98IEEE TNS Vol. 45, No. 6, pg 2483.
MMS	IS61C1024-20M	128K x 8	CMOS (0.5 μ m)	ISS	-2			1.5E-06	1997	>68	CYC	Pooley, et al. 98IEEE Workshop Record, pg 68.
MMS	KMR64002A-17	512K x 8	CMOS/epi, 0.5 μ m feature, Rev A	SAM	-1			1.0E-07	1997		CYC	Pooley, et al. 98IEEE Workshop Record, pg 68.
SNL	M65608	128K x 8	CMOS, 0.5 μ m, commercial	TEM	-1	1.0E-01		1997			BNL	Dodd, et al. 98IEEE TNS Vol. 45, No. 6, pg 2483.
SNL	M65608E	128K x 8	CMOS, 0.5 μ m, rad-tolerant	TEM	-2	8.0E-02		1997			BNL	Dodd, et al. 98IEEE TNS Vol. 45, No. 6, pg 2483.
SNL	M65964	64K Test Vehicle	CMOS, 1.0 μ m, rad-tolerant	TEM	-1	1.0E-01		1997			BNL	Dodd, et al. 98IEEE TNS Vol. 45, No. 6, pg 2483.
MMS	MCH6246WV120	512K x 8	CMOS/epi, 0.5 μ m feat., Rev W51.	MOT	-1			1.0E-07	1997		CYC	Pooley, et al. 98IEEE Workshop Record, pg 68. DiC 9602
SNL	T486	16K Test Vehicle	CMOS, 0.5 μ m, rad-tolerant	SNL	-8	3.0E-03		1997			BNL	Dodd, et al. 98IEEE TNS Vol. 45, No. 6, pg 2483.
Flash Memories												
JPL	28F01USA	2M x 8 or 16M x 1, NOR	ETOX process	INT	7	1.0E-06 to 1.0E-07		Nov-95	44		BNL	Schwartz, et al. 97IEEE TNS, Vol. 44, No. 6, pg 2315. DiC 96??. Functional errors.
JPL	KM29N16KX	2M x 8 NAND	CMOS	SAM	11	2.0E-04	40K	Mar-97	-60		BNL	Schwartz, et al. 97IEEE TNS, Vol. 44, No. 6, pg 2315. DiC 9330. Stuck bits @ LET = 37. All observed upsets probably in peripherals.
JPL	KM29N3200	4M x 8 NAND	DRAM	SAM			64K	Mar-97			BNL	Schwartz, et al. 97IEEE TNS, Vol. 44, No. 6, pg 2315. DiC 96??. No stuck bits.
GSFC	01164001C-70 Rev C	4M x 4	CMOS	IBM	3	7.0E-02		Dec-96	50	2.0E-04	UCB	Label, et al. 96IEEE Workshop Record, pg 19. Cell errors.
GSFC	01164001C-70 Rev C	4M x 4	CMOS	IBM	5	7.0E-02		Dec-96	50	2.0E-04	UCB	Label, et al. 96IEEE Workshop Record, pg 19. Block errors.

TABLE 1 (cont.)
Heavy Ion SEE Testing - 1996 to 1998

Test Org.*	Device	Function	Technology	Mfr.	Effective SEU LET**	Device Xsection (cm ²)	Bit Tested	Bit Xsection (μm ²)	Test Date	L/U _h	LU Xsection (cm ²)	Frac.	Remarks
GSFC 01 16400J1D	4M x 4	CMOS	IBM	<3.8					1996	>11.5			UCB Label, et al. 97 IEEE Workshop Record, pg 14. Bit errors.
GSFC 01 16400J1D	4M x 4	CMOS	IBM	3.9					1996	>11.5			UCB Label, et al. 97 IEEE Workshop Record, pg 14. Bit and block errors.
ESA 01 17400BTIE-60	4M x 4 (3.3 V)	CMOS (IBM - E33)	IBM	-1					4.0E-08	1997			CYC Harboe-Sorensen, et al. 98 IEEE Workshop Record, pg 74.
SEI 14C0164RP	4M x 4	CMOS	HTC	4.5	3.0E-01				Jan-97	>89			UCB Layton, et al. 98 IEEE Workshop Record, pg 170.
JPL D426SI6G5	4M x 16 EDO (5.0 V)	CMOS	NEC	-1					1.0E-15	1998			BNL Swift, RADEC98 preprint. DIC 973KED06. X-section without row or column upsets.
ESA HM51W1610XB	4M x 4 (3.3 V)	CMOS	HTC	<1	1.3E-00				8.0E-16	1997			CYC Harboe-Sorensen, et al. 98 IEEE Workshop Record, pg 74.
ESA KM4AV4100A1	4M x 4 (3.1 V)	CMOS	SAM	<1	4.0E-01				3.0E-16	1997			CYC Harboe-Sorensen, et al. 98 IEEE Workshop Record, pg 74.
JPL KM4RV8104AS-6	8M x 8 EDO	CMOS	SAM	-1	1.3E-00				2.0E-16	1997			BNL Swift, RADEC98 preprint. DIC 9737. Cross section without row or column upsets.
ESA MT41LC4M4D2 Rev T	4M x 4 (3.3 V)	CMOS	MCN	-1					6.0E-08	1997			CYC Harboe-Sorensen, et al. 98 IEEE Workshop Record, pg 74.
JPL TC5165R05AFT-50	8M x 8	CMOS	TOS	-1	1.0E-08					1998			BNL Swift, RADEC98 preprint. DIC 9721. Cross section without row or column upsets.
GSFC TMS416400DJ-60	4M x 4	CMOS	TIX	<2.5						1996	>65		BNL Label, et al. 97 IEEE Workshop Record, pg 14. Bit errors.
ERRORS													
GSFC 2RC010TE	128K x 8	CMOS	HTC	>49						1997	>69		BNL O'Bryan, et al. 98 IEEE Workshop Record, pg 39. Static mode testing.
GSFC 2RC110TE	128K x 8	CMOS	HTC	-20						1997	>69		BNL O'Bryan, et al. 98 IEEE Workshop Record, pg 39. Programming mode testing. Byte errors @ LET = -25; Stuck bits @ -39.7.
GSFC 57256F-35		CMOS	WSI							1997	<18.8		BNL O'Bryan, et al. 98 IEEE Workshop Record, pg 39. DIC 9718
GSFC A55IC(00)1SF-15E	1 Mbit	CMOS	HTC	>37						1997	>37		BNL O'Bryan, et al. 98 IEEE Workshop Record, pg 39. DIC 9646. Static mode testing.
GSFC A55IC(00)1SF-15E	1 Mbit	CMOS	HTC	-18.8						1997	>37		BNL O'Bryan, et al. 98 IEEE Workshop Record, pg 39. Programming mode testing. Block errors and one stuck bit @ LET = 37.
GSFC E28FU1SB	1M x 16 Flash	CMOS	INT	9 to 11.4							26.2 to 1.0E-06		BNL Label, et al. 98 IEEE Workshop Record, pg 19.
Microprocessor (16-bit)													
ARSP MC380C186-12/B	NOP	CMOS III	INT	10	3.0E-04				1997	>63			UCB Crain, et al. 98 IEEE Workshop Record, pg 51. DIC 8951. Lockup errors @ LET = -10.
ARSP MC380C186-12/B	ALU, Bus Unit	CMOS III	INT	10	2.0E-04				1997	>63			UCB Crain, et al. 98 IEEE Workshop Record, pg 51. DIC 8951. Lockup errors @ LET = -10.
ARSP MC380C186-12/B	General register	CMOS III	INT	10	7.0E-04				1997	>63			UCB Crain, et al. 98 IEEE Workshop Record, pg 51. DIC 8951. Lockup errors @ LET = -10.
ARSP MGROC186-12/B	Segment register	CMOS III	INT	10	5.0E-04				1997	>63			UCB Crain, et al. 98 IEEE Workshop Record, pg 51. DIC 8951. Lockup errors @ LET = -10.
ARSP MGROC286-12/883	NOP, ALU	CMOSepi	HAR	10	5.0E-04				1997	>63			UCB Crain, et al. 98 IEEE Workshop Record, pg 51. DIC 8936. Lockup errors @ LET = -5.
ARSP MGROC286-12/883	General register	CMOSepi	HAR	10	1.0E-03				1997	>63			UCB Crain, et al. 98 IEEE Workshop Record, pg 51. DIC 8936. Lockup errors @ LET = -5.
ARSP MGROC286-12/883	Segment register	CMOSepi	HAR	10	7.0E-03				1997	>63			UCB Crain, et al. 98 IEEE Workshop Record, pg 51. DIC 8936. Lockup errors @ LET = -5.
ARSP MGROC286-12/883	Bus Unit	CMOSepi	HAR	7	5.0E-03				1997	>63			UCB Crain, et al. 98 IEEE Workshop Record, pg 51. DIC 8936. Lockup errors @ LET = -5.
Microprocessor (32-bit)													
JPL 6x86-P1 1664-GP	166 MHz Pentium	CMOS	CYR	1.7	1.0E-04				Dec-97				TAM JPL internal report. Cros section @ let = 37.

TABLE 1 (cont.)
Heavy Ion SEE Testing - 1996 to 1998

Test Org.*	Device	Function	Technology	Mfr.	Effective SEU LET**	Device Xsection	Bit Tested	Bit Xsection (μm ²)	Test Date	LUL _{th}	Xsection (cm ²)	Frac.	Remarks
SEI	80486DX2RP	50 MHz test frequency	CHMOS V (0.8 μm), 5.0 V	INT	<5.4	2.0E-03			1997	>40		BNL	Layton, et al., 98IEEE Workshop Record, pg 170 DIC 952757C. Cache on.
SEI	80486DX2RP	50 MHz test frequency	CHMOS V (0.8 μm), 5.0 V	INT	<5.4	1.5E-04			1997	>40		BNL	Layton, et al., 98IEEE Workshop Record, pg 170 DIC 952752C. Cache off.
JSC	80486DX4		3LM CMOS (0.5 μm) - 3.45 V	AMD	1.5	2.5E-03			1996	-5		TAM	Threshold/Cross section with cache enabled. Unsaturated cross section @ LET = 25. 8
JSC	80486DX4		3LM CMOS (0.5 μm) - 3.45 V	AMD	4.5	2.5E-03			1996	-5		TAM	Same as above except threshold/cross section is for cache disabled.
GSFC	H30466A-21		CHMOS IV	SEI	5 to 6				1995	35 to 37.5		BNL	Label, et al., 96IEEE Workshop Record, pg 19. Micro latchup only. Count error cleared by reset.
GSFC	H30466A-21		CHMOS IV	SEI	3.4 to 5				1995	35 to 37.5		BNL	Label, et al., 96IEEE Workshop Record, pg 19. Micro latchup only. Reset errors.
GSFC	H30466A-21		CHMOS IV	SEI	6 to 11.4				1995	35 to 37.5		BNL	Label, et al., 96IEEE Workshop Record, pg 19. Micro latchup only. Lockup cleared by reset.
JPL	K5-PR166ABX	166 MHz Pentium	CMOS (3.5 V)	AMD	<0.4	6.3E-08			Jun-97	0.37	1.3E-06	BNL	Saturated cross section -1.0E-01 cm ⁻² . Destructive latchup
JPL	K5-PR166ABX	166 MHz Pentium	CMOS (3.5 V)	AMD	<1.7	6.3E-08			Dec-97	1.7	1.0E-06	BNL	Saturated cross section -2.0E-03 cm ⁻² . Destructive latchup
GSFC	MQ80486DX2-66		CHMOS V	INT	4.3 to 7.9				1997	26.6 to 37.3		BNL	Dynamic tests with and without cache enabled. Both data and lockup SEE's observed. Also microlatches and saturation errors. @ LET > 25.
GSFC	Mongoose V (R3000)	RISC	CMOS/SOI (Honeywell)	SYN	>83				1997	>96		BNL	O'Bryan, et al., 98IEEE Workshop Record, pg 39. Cache off.
GSFC	Mongoose V (R3000)	RISC	CMOS/SOI (Honeywell)	SYN	-40				1997	>96		BNL	O'Bryan, et al., 98IEEE Workshop Record, pg 39. Cache on.
GSFC	MQ80386-25B		CHMOS IV	INT	4 to 5	8.0E-05				30 to 32		BNL	Label, et al., 96IEEE Workshop Record, pg 19. Micro latchup only. Count or lockup cleared by reset.
GSFC	MQ80386-25B		CHMOS IV	INT	5 to 6	1.5E-03				30 to 32		BNL	Label, et al., 96IEEE Workshop Record, pg 19. Micro latchup only. Lockup cleared by reset.
HON	RH-32		Honeywell HI Process	HON	-30				1997	>83		BNL	Leavy, et al., 98IEEE Workshop Record, pg 11.
<hr/>													
Microprocessor Peripherals													
GSFC	82C54	Timer	CMOS	INT	9				1995	>80		BNL	Label, et al., 96IEEE Workshop Record, pg 19.
GSFC	D8255A-5	Prog. Peripheral Interface	<3.6	INT					1995	59.6		BNL	Label, et al., 96IEEE Workshop Record, pg 19.
MMS	DPR3932CVF	Network Interface Controller	M ² CMOS (1.0 μm)	NSC					1995	15	3.0E-03	GANTL	Pooley, et al., 96IEEE Workshop Record, pg 19.
MMS	DPR3950BVQB	Repeater Interface Controller	M ² CMOS (1.5 μm)	NSC					1995	15	1.0E-03	GANTL	Pooley, et al., 96IEEE Workshop Record, pg 19.
MMS	DPR3956AVL	Repeater Interface Controller	M ² CMOS (1.5 μm)	NSC					1995	20	2.5E-03	GANTL	Pooley, et al., 96IEEE Workshop Record, pg 19.
GSFC	M82C59	Interrupt Controller	CMOS	HAR	11.4				1995	>80		BNL	Label, et al., 96IEEE Workshop Record, pg 19.
GSFC	MQ21380-25B	32-bit Integrated Peripheral	CHMOS III	INT	3.4				1995	15 to 30		BNL	Label, et al., 96IEEE Workshop Record, pg 19. Reset errors cleared by reset.
GSFC	TL7705	Power Supervisor	Bipolar TTL	TX	3.4 to 4.5	8.0E-05			1996	>30		BNL	Microlatches. Also a classic LL or SEE self test.
GSFC	TL7705-5	Power Supervisor	Bipolar TTL	TX	7.5 to 11.6	1.0E-04			1996	>65		BNL	Label, et al., 97IEEE Workshop Record, pg 14.
GSFC	Math Unit	Coprocessor (32-bit)	CHMOS IV	INT	9 to 11.4				1995	32 to 35		BNL	Label, et al., 96IEEE Workshop Record, pg 19. Microlatches observed.
GSFC	MG80387-20B	Op-Amp	Bipolar	NSC	2	<3.0E-03			1997	>60		UCB	Koga, et al., 97IEEE TNS, No. 6, pg. 2325. DIC 9533. No LET _{th} dependence on input voltage delta.
ARSP	LMI08	General Op-Amp											

TABLE 1 (cont.)
Heavy Ion SEE Testing - 1996 to 1998

Test Org.*	Device	Function	Technology	Mfr.	Effective SEU LET**	Device X-section	Test Bias	LU _{in}	LU	Frac.	Remarks
					Threshold	(cm ⁻²)	Test Date	(cm ⁻²)	(cm ⁻²)		
ARSP OR-42	Precision high Speed, fast settling Op-Amp	Bipolar		ADI	2	>2.0E-03	1997	>60	UCB	Koga, et al. 97 IEEE TNS, No. 6, pg. 2325. DIC 9553. No LET _{in} dependence on input voltage delta.	
GSFC OR400	Quad, low power, low offset			PMI	20		1997	>60	BNL	Crain, et al. 98 IEEE Workshop Record, pg. 39. DIC 9711. Transients only. Minimum delta-V = 0.25 V.	
Optoelectronics											
JPL AN49	Single Transistor	890 μm (AGeAs) lateral	HPA				1997				
JPL 6N140	Darlington Amplifier	700 μm (GaAsP) sandwich	HPA	11			1997				
JPL HCP1-5203	Hi-Gain Amp.	700 μm (GaAsP) sandwich	HPA	0.3	>3.8E-03		1997				
JPL HCP1-5611 (6N134)	Hi-Gain Amp.	700 μm (GaAsP) sandwich	HPA	0.3	>2.6E-03		1997				
GSFC HCP1-4651	High speed logic output										
JPL 37-97	Autocorrelator	Bipolar	ORB?	3.5	1.8E-06		Sep 96				
GSFC AD630	Balanced Modulator	Bipolar	ADI	3.38			1996	>65	BNL	Label, et al. 97 IEEE Workshop Record, pg. 14. Short (<20 μs) errors.	
GSFC AD630	Balanced Modulator	Bipolar	ADI	7.4			1996	>65	BNL	Label, et al. 97 IEEE Workshop Record, pg. 14. Medium (20-100 μs) errors.	
GSFC AD630	Balanced Modulator	Bipolar	ADI	7.4			1996	>65	BNL	Label, et al. 97 IEEE Workshop Record, pg. 14. Long (>100 μs) errors.	
GSFC AD632	Voltage-to-Frequency Conv.	Bipolar	ADI	7.4	3.0E-03		1996	>64.7	BNL	Label, et al. 97 IEEE Workshop Record, pg. 14. Single-bit SEUs.	
GSFC AD632	Voltage-to-Frequency Conv.	Bipolar	ADI	7.4	6.0E-03		1996	>64.7	BNL	Label, et al. 97 IEEE Workshop Record, pg. 14. Double-bit SEUs.	
GSFC AD632	Voltage-to-Frequency Conv.	Bipolar	ADI	7.4	1.0E-04		1996	>64.7	BNL	Label, et al. 97 IEEE Workshop Record, pg. 14. Multiple-bit SEUs.	
GSFC FEUGA 15	Image Driver	CMOS	CCT				1997	11.4 to 12	BNL	O'Bryan, et al. 98 IEEE Workshop Record, pg. 39.	
GSFC Q23394DM	Quickswitch	CMOS	QSI				1995	15 to 18	BNL	Label, et al. 96 IEEE Workshop Record, pg. 19.	
ARSP SG1549	Current Sense Latch	Bipolar	SIC	5	>3.0E-04		1997	>60	UCB	Koga, et al. 97 IEEE TNS, No. 6, pg. 2325. DIC 9627	
Voltage Comparators											
ARSP AD9696	Ultra-fast, 200 ps prop. Delay	Bipolar	ADI	6	2.0E-06 - 1.0E-05		1997	>60	UCB	Koga, et al. 97 IEEE TNS, No. 6, pg. 2225. DIC 9605. No LET _{in} dependence on input voltage delta.	
JPL LM111	Single	Bipolar	NSC	<1.45			Apr 96				
ARSP LM1111	Single	Bipolar	NSC	3 to 40	3.0E-06 - 1.0E-04		1997				
ARSP LM1119	Dual	Bipolar	NSC	-3	-1.5E-04		1997				
JPL LM139	Quad	Bipolar	NSC	1.7			Apr 96				
JPL LM139	Quad	Bipolar	PMI	<1.45			Apr 96				
GSFC LM139	Quad	Bipolar	NSC	<10			1997	>37	BNL	O'Bryan, et al. 97 IEEE Workshop Record, pg. 39	
ARSP LM139	Quad	Bipolar	NSC	3 to 40	1.0E-04 - 3.0E-04		1997				
GSFC LM1364H	+2.5 V Reference	Bipolar	NSC	3.38			1996				
Voltage References											
JPL, et al. 97 IEEE Workshop Record, pg. 14. Short (<1 μs) errors.											

TABLE 1 (cont.)
Heavy Ion SEE Testing - 1996 to 1998

Test Org.*	Device	Function	Technology	Mfr.	Effective SEU LET**	Device Xsection	Bit Xsection	Test Date	LU _{th}	Section (cm ²)	Fac.	Remarks
ARSP REF-02	+5 V Reference	Bipolar	ADI	3 to 6	1.0E-04 - 5.0E-04	(cm ²)	(μm ²)	1997	>60		UCB	Koga, et al. 97IEEE TNS, No. 6, pg. 2325. D/C 9305. Weak LET _H dependence on input voltage delta.
Legend:												
Manufacturers: ACT - ACTEL Corp; ADA - Advanced Analog Devices; ADI - Analog Devices, Inc.; AMD - Advanced MicroDevices Corp; AUS - Austin Semiconductor; BJB - Burr-Brown Corp; CCT - C-Cam Technology; CRY - Crystal Semiconductor; CYR - Cypress; DAT - DataI; EXR - Exar Corp; FSC - Fairchild Semiconductor; GTF - Gaefield-HAR - Harris, Corp; HON - Honeywell HPA - Hewlett-Packard; HTC - Hitachi, Ltd; IBM - International Business Machines; IMP - IMP, Inc; INT - Intel Corp; ISS - ISS, Inc; ITP - Interpoint; LMA - Lockheed-Martin; MAT - Matsushita, Corp; MCN - Micron Technologies; MDI - Modular Devices, Inc; MIC - Micrel Semiconductors; MOT - Motorola Semiconductor Products; NEC - NEC Nippon Electric Corp; NSC - National Semiconductor; ORB - Orbis Semiconductors; PFI - Phillips Laboratories; PPS - Performance Semiconductors; PHL - Philips Laboratories; SRS - Sony Corp; SYN - Synova; TEI - Texas Instruments; UTM - United Technologies Microelectronics Center; VSI - Western Semiconductor, Inc; XIL - Xilinx Corp; YAM - Yamata												
Test Organizations					Radiation Facilities							
ARSP - Aerospace Corp, El Segundo CA					BNL - Tandem Van de Graaff, Brookhaven National Laboratories, Long Island, NY							
BALL - Ball Aerospace, Colorado Springs, CO					CYC - CYCLONE, Université Catholique de Louvain-la-Neuve, Belgium							
ESA - European Space Agency, Noordwijk, Netherlands					GANIL - GANIL Accelerator, France							
GSFC - Goddard Space Flight Center, Greenbelt, MD					GSI - Gesellschaft für Schwerionenforschung, Darmstadt, Germany							
HON - Honeywell Space Systems, Clearwater, FL					TAM - Texas A&M University Cyclotron Institute, College Station, TX							
JPL - Jet Propulsion Laboratory, Pasadena, CA					TIARA - Takasaki Ion Accelerators for Advanced Radiation Application, Japan							
JSCE - Johnson Space Flight Center, Houston, TX					UCB - 88-inch Cyclotron, University of California, Berkeley, CA							
LMC - Lockheed-Martin Corp, Sunnyvale, CA												
MMS - Marconi Space, France												
NASDA - National Space Development Agency of Japan, Tokyo, Japan												
SAAB - Ericsson Saab Avionics AB, Linköping, Sweden												
SEI - Space Electronics, Inc, San Diego, CA												
SNL - Sandia National Laboratories, Albuquerque, NM												

TABLE 2
Proton SEE/Transient Compendium

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Device X section (cm ²)	Bit section (cm ²)	Test Date	L.U. _{th}	LU (cm ³)	Frac.	Remarks
Bias Controllers/Drivers												
GSFC	UT1533B RTI	Remote Terminal	CMOS fab I	UTM	var.	>1.0E-19		1997			UCD	O'Bryan, et al. 98IEEE Workshop Record, pg 39.
GSFC	MHF-2815D	DC/DC Power Converters	Hybrid	ADA	51			1997			LLU	O'Bryan, et al. 98IEEE Workshop Record, pg 39.
GSFC	MHF-2815D	Dual output, +1.5 V IN	Hybrid	ADA	51			1997			IUCF	O'Bryan, et al. 98IEEE Workshop Record, pg 39.
GSFC	2706T	Driver Optics	CMOS	FOR	var.			1996			LaBel, et al. 97IEEE Workshop Record, pg 14.	Bit and burst errors.
GSFC	2706R	Fiber Channel Link Rx/cvr	CMOS	FOR	var.			1996			LaBel, et al. 97IEEE Workshop Record, pg 14.	Bit and burst errors.
GSFC	ATTDA204B	Fiber Channel Link X-mitter	CMOS	ATT	var.			1996			LaBel, et al. 97IEEE Workshop Record, pg 14.	Bit and burst errors.
GSFC	ATTDA205B	Fiber Channel Link Rx/cvr	CMOS	ATT	var.			1996			LaBel, et al. 97IEEE Workshop Record, pg 14.	Bit, burst and sync errors.
OTDRs												
GSFC	M6720EV-50	4K x 9	SiCMOS/epi RT	MTA	63		5.6E-14	1996			UND	LaBel, et al. 97IEEE Workshop Record, pg 14.
GSFC	M6720EV-50	4K x 9	SiCMOS/epi RT	MTA	197		8.6E-14	1996			IUCF	LaBel, et al. 97IEEE Workshop Record, pg 14.
GSFC	M6720EV-50	4K x 9	SiCMOS/epi RT	MTA	197		8.3E-11	1996			IUCF	LaBel, et al. 97IEEE Workshop Record, pg 14.
GSFC	M6720EV-50	4K x 9	SiCMOS/epi RT	MTA	197		2.0E-12	1996			IUCF	LaBel, et al. 97IEEE Workshop Record, pg 14.
SRAMs												
GSFC	A1280	8000 equiv. 2-input gates	CMOS/epi (l2 .1μm feature size).	ACT	197			1995			IUCF	LaBel, et al. 96IEEE Workshop Record, pg 19.
GSFC	A1280A	8000 equiv. 2-input gates	CMOS/epi ACT 2 (MAT chip) 1.0 μm feat.	ACT	197			1997			IUCF	O'Bryan, et al. 98IEEE Workshop Record, pg 39.
GSFC	A14100A	10000 equiv. 2-input gates.	CoSiCpi?	ACT	var.	1.3E-13		1996			LaBel, et al. 97IEEE Workshop Record, pg 14.	S-module errors.
GSFC	A14100A	10000 equiv. 2-input gates.	CoSiCpi?	ACT	var.	2.8E-14		1996			LaBel, et al. 97IEEE Workshop Record, pg 14.	I/O module errors.
GSFC	A1460A	6000 equiv. 2-input gates	CMOS/epi (1.0 μm feature size)	ACT	var.			1996			BNL	LaBel, et al. 97IEEE Workshop Record, pg 14.
GSFC	CLAY-31	3134 equiv. gates	RAM-based QAs.	ACT	var.				>90		BNL	LaBel, et al. 97IEEE Workshop Record, pg 14.
GSFC	MK1911	not specified	CMOS, 10 μm cpi (3.1 V)	MT	196				96-97		IUCF	Katz, EEE Links, Vol. 3, No. 2, pg 24, Jun 1997.
GSFC	RH120	8000 equiv. 2-input gates	CMOS/epi (rad-hard LMA, 0.8μm	ACT	20-50	-1.0E-05		1996			IUCF	Katz, EEE Links, Vol. 2, No. 2, Jul 1996
SAAB	XC4010E-4	10000 equiv. gates.	CMOS, 0.6μm (3.0 V)	XIL	100		1.3E-15	1997			TSL	Ohlsson, et al. DIC 9612, 17K bits tested.
SAAB	XC4010XL-4	10000 equiv. gates.	CMOS, 0.55μm (3.3 V)	XIL	100		4.4E-15	1997			TSL	Ohlsson, et al. DIC 9733, 25K bits tested.
Gate Arrays/ALP/FPGAs												
GSFC	IMP50E10	Elect. Programmable Analog Circ.	CMOS	IMP	197			1997			LaBel, et al. 96IEEE Workshop Record, pg 19.	
GSFC	J722V10-10	PLA	CMOS	CYP	var.			1997			BNL	O'Bryan, et al. 98IEEE Workshop Record, pg 39.
GSFC	DR1773	1773 Bus Transceiver.	CMOS?	BOE	var.	1.4E-10		1996			LaBel, et al. 97IEEE Workshop Record, pg 14.	Attenuation and angle dependent.

TABLE 2 (cont.)
Proton SEE/Transient Compendium

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Xsection (cm ⁻²)	Test Xsection (cm ⁻²)	Date	L1U _{th}	LU Xsection (cm ⁻²)	Frac.	Remarks
GSFC DR1773	1773 Bus Transceiver.	Cmos(?)	BOE	var.	<2.0E-11			1996				Label, et al. 97 IEEE Workshop Record, pg 14. Receive mode. Attenuation and angle dependent.
GSFC SAALS05	Hex Inverter	Bipolar-LSTTL	TIX	var.				1997				O'Bryan, et al. 98 IEEE Workshop Record, pg 39. No SEU.
GSFC SAALS055	Hex Non-Inverting Buffer	Bipolar-LSTTL	TIX	var.				1997				O'Bryan, et al. 98 IEEE Workshop Record, pg 39. No SEU.
GSFC SAALS03	Quad 2-input NOR	Bipolar-LSTTL	TIX	var.				1997				O'Bryan, et al. 98 IEEE Workshop Record, pg 39. No SEU.
GSFC 70V25	8K x 16 Dual Port SRAM	CMOS	IDT	26.6 - 63				1995				UCD Label, et al. 96 IEEE Workshop Record, pg 19. SBE @ LET = 26.6. No MBE up to LET = 63.
MNS ASSC400RCW-35E	512K x 8	CMOS/epi, 0.5 μm feature size	MOT	10		1.5E-13						PSI Poivey, et al. 98 IEEE Workshop Record, pg 68. DIC 9731. MOT chips packaged by Austin.
ESA CK1000AM-70LL	128K x 8	CMOS	SNY	60		2.2E-14	Nov-96					CYC Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 1992
ESA CK1000AM-70L	128K x 8	CMOS	SNY	60		8.7E-14	Nov-96					CYC Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 1992
ESA CK1000P-10L	128K x 8	CMOS	SNY	500		4.1E-15	Apr-91					SAT Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 9714E
MNS CXK5100KBP-10LL	128K x 8	CMOS	SNY	10		3.5E-14	1997					PSI Poivey, et al. 98 IEEE Workshop Record, pg 68.
ESA CXK52258P-35	32K x 8	CMOS	SNY	30		7.5E-15	Apr-91					SAT Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 9FME
ESA CXK52258P-35	32K x 8	CMOS	SNY	500		3.0E-13	Apr-91					SAT Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 9FME
ESA CY7C67-35DC	16K x 1	CMOS	CYP				Nov-89	209	<1.0E-13			PSI Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 8742
ESA CY7C185-25DC	8K x 8	CMOS	CYP	300		1.3E-12	Aug-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 9214
ESA CY7C185-35DC	8K x 8	CMOS	CYP	300		1.4E-12	Aug-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 9006
ESA CYC128-35DC	2K x 8	CMOS	CYP	300		2.1E-12	Aug-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 8852
ESA CYC128A-35DC	2K x 8	CMOS	CYP	300		1.3E-12	Aug-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 8847
ESA D431000ACZ-85LL	128K x 8	CMOS	NEC	300		1.0E-13	May-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 9146
ESA D43250AC10LL	32K x 8	CMOS	NEC	209		4.7E-13	Nov-89					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 8839
ESA D4364C-20L	8K x 8	CMOS	NEC	60		1.4E-14	Nov-89					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 8436
ESA D4364C-20L	8K x 8	CMOS	NEC	209		9.7E-15	Feb-92					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 8436
ESA D4464C-15	8K x 8	CMOS	NEC				Sep-92	50	<1.0E-13			PSI Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 8945
ESA D4464G-15L	8K x 8	CMOS	NEC				Feb-92	33	<1.0E-13			PSI Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 8622
ESA EDH8832C10 KMHR	32K x 8	CMOS	EDI	50		1.8E-13	Apr-91					SAT Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 8652
ESA EDH8832C100CL	32K x 8	CMOS	EDI	50		9.5E-14	Mar-91					SAT Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 8936
ESA EDH8832C100CL	32K x 8	CMOS	EDI	50		1.3E-14	Apr-91					SAT Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 8936
ESA EDH8832C100CL	32K x 8	CMOS	EDI	100		9.3E-13	Nov-89					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 8936

TABLE 2 (cont.)

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Device X-section (cm ²)	Bit Tested	Bit X-section (cm ²)	Test Date	LU _{th} (cm ³)	LU (cm ³)	Fac.	Proton SEE/Transient Compendium		Remarks
													Test	X-section (cm ²)	
ESA	EDH8822C-151MHR	32K x 8	CMOS	EDI	50		1.8E-13	Apr-91				SAT	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 0738		13-Aug-99
ESA	ED18806CB-35QB	8K x 8	CMOS	EDI	300		2.0E-12	Aug-94				PSI	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 9103		
ESA	ED18810L-150DB	8K x 8	CMOS	EDI				Aug-94	<1.0E-13	209		PSI	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 9033		
ESA	ED188128C100CM	128K x 8	CMOS	EDI	500		1.3E-13	Apr-91				SAT	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 9102		
ESA	ED188130H45CM	128K x 8	CMOS	EDI	300		2.5E-13	Apr-93				PSI	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 9111		
ESA	HM1-65104-2	4K x 1	CMOS	HAR	60		<5.3E-15	Jun-89				VEC	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8122		
ESA	HM1-65104-5	4K x 1	CMOS	HAR	60		<5.3E-15	Jun-89				VEC	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 7943		
ESA	HM1-65104-9	4K x 1	CMOS	HAR	209		<8.4E-15	Nov-89				PSI	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8508		
ESA	HM1-65162-2	2K x 8	CMOS	MHS	100		4.2E-13	Nov-89				PSI	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8740		
ESA	HM1-65162-2	2K x 8	CMOS	MHS	200		5.0E-13	Apr-93				PSI	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8740		
ESA	HM1-65162-2	2K x 8	CMOS	MHS	300		7.6E-13	Apr-93				PSI	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8902		
ESA	HM1-6516-9	2K x 8	CMOS	HAR	60		2.4E-14	Jun-89				VEC	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8313		
ESA	HM1-6516-9	2K x 8	CMOS	HAR	100		1.5E-13	Nov-89				PSI	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8313		
ESA	HM1-65262-2	16K x 1	CMOS	MHS	100		1.5E-13	Nov-89				PSI	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8714		
ESA	HM1F-65664B-2	8K x 8	CMOS	MHS	50		<2.0E-14	Apr-93				PSI	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8914		
ESA	HM1F-65664B-2	8K x 8	CMOS	MHS	300		1.5E-13	Apr-93				PSI	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8313		
ESA	HM6116P-3	2K x 8	CMOS	HTC	45		1.1E-14	Jun-89				VEC	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8638		
ESA	HM6116P-3	2K x 8	CMOS	HTC	209		5.8E-13	Nov-89				PSI	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8638		
ESA	HM6116P-3	2K x 8	CMOS	HTC	500		3.6E-13	Apr-91				SAT	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8638		
ESA	HM6116P-3	2K x 8	CMOS	HTC	100		1.2E-13	Apr-91				PSI	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8638		
ESA	HM6254P-10	32K x 8	CMOS	HTC	45		3.9E-14	Jun-89				PSI	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8117		
ESA	HM6254P-10	32K x 8	CMOS	HTC	209		1.6E-13	Nov-89				PSI	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8413		
ESA	HM6254P-10	32K x 8	CMOS	HTC	500		2.9E-13	Apr-91				SAT	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8817		
ESA	HM6254P-10	32K x 8	CMOS	HTC	100		1.2E-13	Apr-91				SAT	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8901		
ESA	HM6254LP-15	8K x 8	CMOS	HTC	45		3.9E-14	Jun-89				VEC	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8413		
ESA	HM6254LP-15	8K x 8	CMOS	HTC	100		1.2E-13	Apr-93				PSI	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8413		
ESA	HM6254LP-15	8K x 8	CMOS	HTC	500		2.9E-13	Apr-93				SAT	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 8413		
MMS	HM628128BLP-7	128K x 8	HCMOS: 0.8 µm features, Rev B	HTC	18		3.0E-14	1997				PSI	Ponvey, et al., 98IEEE Workshop Record, pg. 68. D/C 9713		
ESA	HM628128L-10	128K x 8	CMOS	HTC	500		1.0E-13	Apr-91				SAT	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 9009		
ESA	HM628128L-10	128K x 8	CMOS	HTC	300		9.0E-13	Apr-93				PSI	Harboe-Sorensen, RADECSS7 Data Workshop, pg. 89. D/C 9009		

TABLE 2 (cont.)
Proton SEE/Transient Compendium

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Device Xsection (cm ²)	Bits Tested	Xsection (cm ²)	Test Date	LU _h	LU Execution (cm ²)	Fac.	Remarks
MMS	HMC26512ALP-7	512K x 8	HCMOS, 0.5 μm features, Rev B.	HTC	10	1.0E-13	1997					PSI	Puvey, et al. 98IEEE Workshop Record, pg 68. DIC 9705
ESA	HMC26512B-7	128K x 8	CMOS	HTC	300	2.5E-13	May-94					PSI	Harboe-Sorensen, RADEC97 Data Workshop, pg 89. DIC 9735
ESA	HM-65656	32K x 8	CMOS	MHS	300	3.9E-13	Apr-93					PSI	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC (sample)
ESA	HM-65656E	32K x 8	CMOS	MHS	33	1.6E-13	Apr-93					PSI	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC (sample)
ESA	HMC65687E	64K x 1	CMOS	MHS	100	1.4E-14	Apr-93					PSI	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC (sample)
ESA	IDT1256 OC	256K x 1	CMOS	MHS	300	4.0E-13	Apr-93					PSI	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC (sample)
ESA	HMCCE-65664B-8	8K x 8	CMOS	MHS	100	3.9E-14	Apr-91					PSI	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9232
ESA	IDT1256 BBC	32K x 8	CMOS	IDT	500	2.4E-13	Apr-89					SAT	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8943
ESA	IDT1256 OC	32K x 8	CMOS	IDT	500	2.9E-13	Apr-89					SAT	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9103BL
ESA	IDT164	8K x 8	CMOS	IDT	50	2.9E-14	Apr-91					SAT	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC RE9101BI
ESA	IDT164	8K x 8	CMOS	IDT	500	1.7E-13	Apr-91					SAT	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC RE9101BI
ESA	IMS160055 ABF	64K x 1	CMOS	ISM	100	5.1E-13	Nov-89					PSI	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8534
MMS	IS61C1024-20M	128K x 8	CMOS (0.5 μm)	ISS	10	2.0E-13	1997					PSI	Puvey, et al. 98IEEE Workshop Record, pg 68.
ESA	KM68100LP-8	128K x 8	CMOS	SAM	300	3.0E-13	May-94					PSI	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 214Y
ESA	KM6840000LP-5	128K x 1	CMOS	SAM	300	2.0E-13	May-94					PSI	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 310Y
MMS	KM664002AJ-17	512K x 8	CMOS/epi, 0.5 μm feature, Rev A	SAM	14	4.0E-16	1997					PSI	Puvey, et al. 98IEEE Workshop Record, pg 68.
ESA	MSK65568BP-15	32K x 8	CMOS	MIT	50	6.0E-14	Apr-91					SAT	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9271
ESA	MA56116	2K x 8	CMOS	MMS	100	3.0E-13	Nov-89					PSI	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8737
ESA	MA56116	2K x 8	CMOS	MMS	200	<2.0E-15	Nov-89					PSI	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8737
ESA	MBIC81A-45	256K x 1	CMOS	FUJ	500	1.6E-13	Apr-91					SAT	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8820
ESA	MB4256-10L	32K x 8	CMOS	FUJ	800	5.0E-13	Mar-91					SAT	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8948
ESA	MB4256-10L	32K x 8	CMOS	FUJ	500	3.7E-13	Apr-91					SAT	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8948
ESA	MB84256-15L	32K x 8	CMOS	FUJ	500	4.7E-15	Apr-91					SAT	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8650
ESA	MB464-15	8K x 8	CMOS	FUJ	209	3.7E-13	Nov-89					PSI	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8431
MMS	MC4624SW/720	512K x 8	CMOS/epi, 0.5 μm feat., Rev W51.	MOT	8	3.0E-14	1997					PSI	Puvey, et al. 98IEEE Workshop Record, pg 68. DIC 9602
ESA	MM-1-6504H11	4K x 1	CMOS	MHS	60	1.0E-14	Jun-89					VEC	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8619
ESA	MM-1-6504H11	4K x 1	CMOS	MHS	100	9.0E-14	Nov-89					PSI	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8619
ESA	MSN8125-70	128K x 8	CMOS	MPC	300	1.5E-14	Apr-93					PSI	Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9210

TABLE 2 (cont.)
Proton SEE/Transient Compendium

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Device Xsection (cm ²)	Bit Tested Xsection (cm ²)	Test Date	LU _h	LU	Xsection (cm ²)	Frac.	Remarks
													[3 Aug 99]
ESA	MSM8128S-35	128K x 8	CMOS	MPC	300		8.4E-14	Apr-93					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9252
ESA	MSM8128SLMB-45	128K x 8	CMOS	MPC	300		3.4E-15	Apr-93					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9108
ESA	MSM8128SLMB-45	128K x 8	CMOS	MPC	300		1.1E-14	May-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9108
ESA	MT5C108C-25	128K x 8	CMOS	MCN	500		2.8E-13	Apr-91					SAT Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9110
ESA	MT5C226 S12D	32K x 8	CMOS	MCN	200		2.3E-15	Aug-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 1937?
ESA	MT5C256B S02A	32K x 8	CMOS	MCN	30		9.0E-14	May-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9231
ESA	MT5C256S S02A	32K x 8	CMOS	MCN	300		1.4E-14	May-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9231
ESA	P4C125T-35CC	256K x 1	CMOS	PPS	500		9.4E-15	Apr-91					SAT Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8943
ESA	QS3280-15P	32K x 8	CMOS	QSI				Aug-94	30	<1.0E-13			PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9312
ESA	SM16ICD16LA-25	16K x 1	CMOS	TTX				Nov-89	209	<1.0E-13			PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8904
ESA	TC551001BPL-70L	128K x 8	CMOS	TOS	60		1.0E-14	Nov-96					CYC Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9623
ESA	TC551001BPL-70L	128K x 8	CMOS	TOS	60		7.0E-14	Nov-96					CYC Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9623
ESA	TC5516AP-2	2K x 8	CMOS	TOS	100		5.9E-14	Apr-91					SAT Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8333
ESA	TC5516AP-2	2K x 8	CMOS	TOS	500		1.6E-13	Apr-91					SAT Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8333
ESA	TC5516AP-2	2K x 8	CMOS	TOS	45.4		4.1E-15	Jun-89					VEC Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8340
ESA	TC55155P-10	32K x 8	CMOS	TOS	209		1.0E-13	Nov-89					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8640
ESA	TC5564PL-15	8K x 8	CMOS	TOS				Jun-89	60	<1.0E-13			VEC Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8514
ESA	TC5564PL-15	8K x 8	CMOS	TOS				Nov-89	209	<1.0E-13			PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8646
ESA	TC55812SP-20	128K x 8	CMOS	TOS	300		2.1E-13	May-96					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9230
ESA	UM62256-10L	32K x 8	CMOS	UTM	300		1.8E-13	May-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9036
<hr/> Flash Memories <hr/>													
ESA	AM29LV800B-120	1M x 8	CMOS	AMD	60		6.0E-18	Nov-96					CYC Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9625. V _{DD} = 3.3. Read mode.
ESA	CAT28F10P-15 OES	128K x 8	CMOS	CAT	300		<8.8E-17	May-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9213. Read mode.
ESA	M28F101-150PI VP8	128K x 8	CMOS	SCS	3W		<8.8E-17	May-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9344. Read mode.
ESA	M28F56-15BI VP8A	32K x 8	CMOS	SGS	300		<3.5E-16	May-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9319. Read mode.
ESA	M5M28F101P-12	128K x 8	CMOS	MIT	300		<8.8E-17	May-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 312107. Read mode.
ESA	P28R101-20	128K x 8	CMOS	INT	300		<7.6E-17	May-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 113602P1. Read mode.
ESA	P28F112-120	64K x 1	CMOS	INT	300		<1.5E-16	May-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 110938P2. Read mode.

TABLE 2 (cont.)
Proton SEE/Transient Compendium

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Bits	Device X-section (cm ⁻²)	Test Date	L/L _{th}	X-section (cm ⁻²)	LU	Fat.	PSI	Remarks
13-Aug-99														
ESA	TMS25F12-120C3NL	64K x 1	CMOS	TIX	300		<1E-16	May-94						
DRAM														
GIFC	pPD216400-40	4M x 4	CMOS (5.0 V)	NEC	197		7.8E-12	1996			IUCF	LaBe, et al., 97 IEEE Workshop Record, pg 14. Bit errors.		
GIFC	01164001C-70	4M x 4 (5.0 V)	CMOS	IBM	63	2.0E-07		1995			UCD	LaBe, et al., 96 IEEE Workshop Record, pg 19. Cell errors.		
GIFC	01164001C-70	160 Mbit stack (5.0 V)	CMOS	IBM	197			1995			UCD	LaBe, et al., 97 IEEE Workshop Record, pg 19. No errors.		
GIFC	01164001ID	4M x 4 (5.0 V)	CMOS	IBM	63		1.5E-15	1996			UCD	LaBe, et al., 97 IEEE Workshop Record, pg 14. Bit and block errors.		
GIFC	01164001ID	4M x 4 (3.1 V)	CMOS	IBM	63		1.5E-15	1996			UCD	LaBe, et al., 97 IEEE Workshop Record, pg 14. Bit and block errors.		
GIFC	011640PT1C-70	4M x 4 (3.3 V)	CMOS	IBM	63	2.0E-09		1995			UCD	LaBe, et al., 96 IEEE Workshop Record, pg 19. Cell and block errors.		
ESA	011740BTE-60	4M x 4 (3.3 V)	CMOS (IBM - ES3)	IBM	15		1.5E-15	1997			PSI	Hartoe-Sorensen, et al., 91 IEEE Workshop Record, pg 74.		
ESA	011740BTF-60	4M x 4 (3.3 V)	CMOS (IBM - ES4)	IBM	11		9.0E-16	1997			PSI	Hartoe-Sorensen, et al., 91 IEEE Workshop Record, pg 74.		
ESA	01400MMUD	4M x 1	CMOS	IBM	300		2.1E-15	Aug-94			PSI	Hartoe-Sorensen, et al., 91 IEEE Workshop Record, pg 89. DIC 9314.		
GIFC	431640-70	4M x 4 (5.0 V)	CMOS	NEC	63	5.0E-07		1995			UCD	LaBe, et al., 96 IEEE Workshop Record, pg 19. Cell errors.		
GIFC	43G240	4M x 4 (3.3 V)	CMOS	IBM	63	6.0E-09		1995			UCD	LaBe, et al., 96 IEEE Workshop Record, pg 19. Cell and block errors.		
ESA	404000JC-00E	4M x 1	CMOS	MCN	300		7.4E-14	May-94			PSI	Hartoe-Sorensen, et al., 91 IEEE Workshop Record, pg 89. DIC 9244.		
ESA	63FB221N1326TC	4M x 4	CMOS	IBM	300		<4.8E-19	Aug-94			PSI	Hartoe-Sorensen, et al., 91 IEEE Workshop Record, pg 89. DIC 9314. Row/Column/Block Errors.		
ESA	8116100-60P1T32	16M x 1	CMOS	FUJ	300		2.3E-14	Aug-94			PSI	Hartoe-Sorensen, et al., 91 IEEE Workshop Record, pg 89. DIC 9305.		
GIFC	881304SPC	128K x 8	CMOS	HTC	63		1.7E-13	1996			UCD	LaBe, et al., 97 IEEE Workshop Record, pg 14. Bit errors.		
ESA	D42100KC-10	1M x 1	CMOS	NEC	209		7.3E-13	Nov-89			PSI	Hartoe-Sorensen, et al., 91 IEEE Workshop Record, pg 89. DIC 8839.		
ESA	D421610NV-70	16M x 1	CMOS	NEC	300		4.7E-14	Aug-94			PSI	Hartoe-Sorensen, et al., 91 IEEE Workshop Record, pg 89. DIC 9249.		
GIFC	D421640NC3-70	4M x 4 (3.3 V)	CMOS	NEC	63	2.0E-07		1995			UCD	LaBe, et al., 96 IEEE Workshop Record, pg 19. Cell errors.		
ESA	D42100V-80	4M x 1	CMOS	NEC	500		4.1E-13	Apr-91			SAT	Hartoe-Sorensen, et al., 91 IEEE Workshop Record, pg 89. DIC 9005.		
ESA	D424256C-80	256K x 4	CMOS	NEC	209		8.9E-13	Nov-89			PSI	Hartoe-Sorensen, et al., 91 IEEE Workshop Record, pg 89. DIC 8923.		
ESA	D424256V-80	256K x 4	CMOS	NEC	500						SAT	Hartoe-Sorensen, et al., 91 IEEE Workshop Record, pg 89. DIC 8919.		
ESA	ED14410DC (072C	4M x 1	CMOS	EDI	500		4.6E-14	Apr-91			SAT	Hartoe-Sorensen, et al., 91 IEEE Workshop Record, pg 89. DIC 9110.		
ESA	HM5116100Z8	16M x 1	CMOS	HTC	300		3.5E-14	Aug-94			PSI	Hartoe-Sorensen, et al., 91 IEEE Workshop Record, pg 89. DIC 9228.. Stuck bit @ 51 MeV.		
GIFC	HM511600AJ7	4M x 4	CMOS (5.0 V)	HTC	63	2.0E-07		1995			UCD	LaBe, et al., 96 IEEE Workshop Record, pg 19. Cell errors.		
ESA	HM511600Z8	4M x 4	CMOS	HTC	300		4.0E-14	Aug-94			PSI	Hartoe-Sorensen, et al., 91 IEEE Workshop Record, pg 89. DIC 9233.. Stuck bit @ 100 MeV		
ESA	HM5116500A56	4M x 4	CMOS	HTC	200		1.3E-14	Aug-94			PSI	Hartoe-Sorensen, et al., 91 IEEE Workshop Record, pg 89. DIC 9402.. Stuck bit @ 100 MeV.		

TABLE 2 (cont.)
Proton SEE/Transient Compendium

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Device Xsection (cm ²)	Bit Xsection (cm ²)	Test Date	L.U _{th}	L.U	Xsection (cm ²)	Frac.	Remarks
													13-Aug-99
ESA	HM514100ZP8	4M x 1	CMOS	HTC	300		6.4E-13	May-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C 90/10
ESA	HM51W16100B	4M x 4 (3.3 V)	CMOS	HTC	11			1.5E-14	1997				PSI Harboe-Sorensen, et al. 98IEEE Workshop Record, pg 74.
ESA	HYB51100A-70	1M x 1	CMOS	SIE	209			4.0E-13	Nov-99				PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C 88/46
ESA	HYB514100J-10	4M x 1	CMOS	SIE	500		3.5E-13	Apr-91					SAT Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C 00/8
ESA	HYB514256-70	256K x 4	CMOS	SIE	500		1.2E-13	Apr-91					SAT Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C 90/28
ESA	IBM401070804 5352	4M x 4	CMOS	IBM	200		8.0E-13	Aug-94					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C 92/37. 1 Block Errr @ 200MeV.
ESA	KM44C16000J-7	16M x 1	CMOS	SAM	300		4.4E-14	1994					PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C 31/1
ESA	KM44C4000J-8	4M x 1	CMOS	SAM	500		4.8E-14						
ESA	KM44AV4100AJ	4M x 4 (3.3 V)	CMOS	SAM	10		7.8E-14	Apr-91					SAT Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C 01/9
ESA	KM44AV4100B	4M x 4 (3.3 V)	CMOS	SAM	10		5.0E-14	1997					PSI Harboe-Sorensen, et al. 98IEEE Workshop Record, pg 74.
GSFC	KM44AV8100AS-16	8M x 8	CMOS	SAM	63		1.0E-14	1996					UCD LaBell, et al. 97IEEE Workshop Record, pg 14. Bit errors.
HON	KM48V8100AS-16	8M x 8	CMOS	SAM	-63		4.0E-07						UCD Ash, et al. 1999 COTS Workshop Proceedings, pg 287.
ESA	LU1A ES/3	4M x 4	CMOS	IBM	60			2.0E-14	1997				PSI Harboe-Sorensen, et al. 98IEEE Workshop Record, pg 74.
ESA	LU1A ES/3	4M x 4	CMOS	IBM	60			1.9E-16	Nov-96				UCD LaBell, et al. 97IEEE Workshop Record, pg 14. Bit errors.
GSFC	LU1A-ES Rev C	4M x 4	CMOS/Septi	IBM					Jun-98				UCD Ash, et al. 1999 COTS Workshop Proceedings, pg 287.
ESA	M51510A/RU1 9AUZ	4M x 1	CMOS	OKI	500		8.2E-14	Apr-91					CYC Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C none. V _{DD} = 4.5 V.
ESA	M3M44C256P	256K x 4	CMOS	MIT	209			2.7E-13	Nov-89				CYC Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C none. V _{DD} = 3.3 V.
ESA	M3M4C100NP	1M x 1	CMOS	MIT	209				1997				var. O'Bryan, et al. 98IEEE Workshop Record, pg 39. Bit pointer & functionality interrupt errors
ESA	MBB14100-10FSZ	4M x 1	CMOS	FUJ	500				8.2E-14	Apr-91			SAT Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C 90/10
ESA	MCM51410X/Z80	4M x 1	CMOS	MOT	500				2.3E-13	Apr-91			SAT Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C 86/2
ESA	MT4AC100AC	4M x 1	CMOS	MCM	500				3.1E-13	Nov-89			PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C 715/2E-2/2
ESA	MT4AC100D	4M x 1	CMOS	MCM	300				1.7E-13	Apr-91			SAT Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C 90/25
ESA	MT4CM4BD1D2A	4M x 1	CMOS	MCM	300				2.3E-13	Apr-91			SAT Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C 89/51.
ESA	MT4CM4BD1DW	4M x 4	CMOS	MCM	300				9.1E-14	Apr-91			SAT Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C 91/02
ESA	MT4LC4001 D22	4M x 1	CMOS	MCM	200				7.3E-14	May-94			PSI Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C 92/34C
ESA	MT4LC4M4BD1-6	4M x 4 (3.3 V)	CMOS	MCM	14				8.0E-15	1997			PSI Harboe-Sorensen, et al. 98IEEE Workshop Record, pg 74.
ESA	MT4LC4M4ENTG	4M x 4 (3.3 V)	CMOS	MCM	11				2.7E-15	Nov-96			PSI Harboe-Sorensen, et al. 98IEEE Workshop Record, pg 74.
ESA	MT4LC4MB1D2RM	4M x 4	CMOS	MCM	60				4.9E-15	Nov-96			CYC Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C none. V _{DD} = 4.5 V.
ESA	MT4LC4MB1D2RM	4M x 4	CMOS	MCM									CYC Harboe-Sorensen, RADEC97 Data Workshop, pg. 89. D/C none. V _{DD} = 3.3 V.

TABLE 2 (cont.)
Proton SEE/Transient Compendium

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Device X-section (cm ²)	Bit X-section (cm ²)	Test Date	L _U _{th}	L _U (cm ²)	Fac.	Remarks
GSFC	MT5C18R0CW-25	128K x 8 (5.5 V)	CMOS	MCN	63		4.8E-17	1996			UCD	LaBel, et al. 97IEEE Workshop Record, pg 14. Bit errors.
GSFC	SMA44100	4M x 16 EDIO (5.5 V)	CMOS/Opamp	TIX	<25		3.5E-13	1992			SAT	Duzalier, et al. 93IEEE TNS preprint (not published). DIC/ES. Also has proton data.
ESA	SMA4C1024-12IDM	1M x 1	CMOS	TIX	209		4.7E-13	Nov-89			PSI	Hartoe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8840
ESA	SMA44100-80HLM	4M x 1	CMOS	TIX	300		2.6E-13	May-94			PSI	Hartoe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9218. B
ESA	TC51100AAP-10	1M x 1	CMOS	TOS	209		3.7E-13	Nov-89			PSI	Hartoe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8748
ESA	TC51164(X)0-60	4M x 4	CMOS	TOS	300		1.6E-13	Aug-94			PSI	Hartoe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9334MCD
ESA	TC514100Z-10 HDK	4M x 1	CMOS	TOS	500		2.3E-13	Apr-91			SAT	Hartoe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 9097
ESA	TC51425RF-10	256K x 4	CMOS	TOS	209		3.9E-13	Nov-89			PSI	Hartoe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8811
ESA	TM53416400A	4M x 4	CMOS	TIX	300		3.7E-14	Aug-94			PSI	Hartoe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC none.
GSFC	TM53416400D1-60	4M x 4	CMOS	TIX	197		5.4E-12	1996			IUCF	LaBel, et al. 97IEEE Workshop Record, pg 14. Bit errors.
ESA	TM534100DM-80	4M x 1	CMOS	TIX	500		2.2E-13	Apr-91			SAT	Hartoe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 0485
ESA	TM53416-12NL	16K x 4	CMOS	TIX	209		1.4E-12	Nov-89			PSI	Hartoe-Sorensen, RADEC97 Data Workshop, pg. 89. DIC 8844
GSFC	TP0116400A13B-70	4M x 4	CMOS	IBM	63	6.0E-09		1995			UCD	LaBel, et al. 96IEEE Workshop Record, pg 19. Bit errors and one block error.
Microprocessors (32 bit)												
SEI	80486DX2RP		CHMOS V (0.1 μm)	INT	63	1.0E-09		1997			UCD	Layton, et al. 91IEEE Workshop Record, pg 170.DIC 932752C. Cross section with cache on.
JPL	K5-PR168ABX	Pentium	CMOS (3.5 V)	AMD	195			Jun-97		5.6E-09	IUCF	Miyahira, Preliminary JPL Report.
Optocouplers												
GSFC	632123	Optocoupler		MPC	58			1997			TRI	OByran, et al. 98IEEE Workshop Record, pg 39. SETs but showed CTR degradation.
GSFC	662088	Optocoupler		MPC	63			1997			UCD	OByran, et al. 98IEEE Workshop Record, pg 39. No SETs observed.
GSFC	66099	Optocoupler		MPC	58			1997			TRI	OByran, et al. 98IEEE Workshop Record, pg 39. No SETs observed.
GSFC	4N48	Optocoupler		OPT	63			1997			UCD	OByran, et al. 98IEEE Workshop Record, pg 39. No SETs or CTR degradation.
GSFC	4N49	Optocoupler		MPC	58			1997			TRI	OByran, et al. 98IEEE Workshop Record, pg 39. No SETs observed.
GSFC	4N55	Optocoupler		HPA	63			1997			UCD	OByran, et al. 98IEEE Workshop Record, pg 39. No SETs observed.
GSFC	6N136	Optocoupler		MPC	63			1997			UCD	OByran, et al. 98IEEE Workshop Record, pg 39. No SETs observed.
GSFC	6N140	Darlington Amplifier	700 μm (GaAsP) sandwich	MPC	58			1997			TRI	OByran, et al. 98IEEE Workshop Record, pg 39. No SETs observed.
GSFC	6N140A	Darlington Amplifier	700 μm (GaAsP) sandwich	HPA	63			1997			BNL	OByran, et al. 98IEEE Workshop Record, pg 39. DIC 9707. No SETs observed.
GSFC	HCPL-5401	Optocoupler		HPA	63	8.5E-08		1997			UCD	OByran, et al. 98IEEE Workshop Record, pg 39. 20-25 ns SETs observed with device unbiased.
GSFC	HCPL-5631	Hi-Gain Amp.	700 μm (GaAsP) sandwich	HPA	63	3.5E-08		1997			UCD	LaBel, et al. 97IEEE TNS, Vol. 44, No. 6, pg 1885. DIC9247 & 9707.
GSFC	HCPL-5631	Hi-Gain Amp.	700 μm (GaAsP) sandwich	HPA	38.2	4.5E-08		1997			UCD	LaBel, et al. 97IEEE TNS, Vol. 44, No. 6, pg 1885. DIC 9247 & 9707.

TABLE 2 (cont.)
Proton SEE/Transient Compendium

Test Org.*	Device	Function	Technology	Proton SEE/Transient Compendium								Remarks
				Mfr.	Proton Energy (MeV)	Device X-section (cm ⁻²)	Bit Test Date	L _U _{th}	L _U X-section (cm ⁻²)	Fac.		
GSEFC	HCP2L-5631 (6N134)	Hi-Gain Amp.	700 μm (GaAsP) sandwich	HPA	var.		1997					O'Bryan, et al. 98IEEE Workshop Record, pg 39. SETs observed.
GSEFC	HCP2L-6651	Optocoupler		HPA	220	1.0E-08		1997				TRI O'Bryan, et al. 98IEEE Workshop Record, pg 39. SETs observed.
GSEFC	HCP2L-6651	Optocoupler		HPA	70	1.0E-07		1997				ICUF O'Bryan, et al. 98IEEE Workshop Record, pg 39. SETs observed. No CTR degradation. Cross section @ 90°.
GSEFC	HCP2L-6651	Optocoupler		HPA	58	1.0E-07		1997				TRI O'Bryan, et al. 98IEEE Workshop Record, pg 39. No SETs or CTR degradation without active or passive filters. SETs but no CTR degradation without filters..
GSEFC	HSSR-7110	Power MOSFET Optocoupler	AlGaAs LED; n-channel MOSFET	HPA	var.							LaBel, et al. EEELinks, Vol. 3, No. 1, pg 5. Mar 1997. No SEE.
GSEFC	SEDA	1773 1MHz F/O Bus		SCI	63			1997				UCD O'Bryan, et al. 98IEEE Workshop Record, pg 39. Proton-induced SEUs.
Voltage Comparitors												
JPL	LM139	Quad	Bipolar	NSC	200	3.2E-11		Feb-96				IUCF Transients only, +25mV input delta.
JPL	LM139	Quad	Bipolar	NSC	200	1.2E-10		Feb-96				IUCF Transients only, +25mV input delta.
Legend:												
Manufacturers: ACT - ACTEL, Corp; ADA - Advanced Analog Devices; AMD - Advanced Microdevices Corp; ASI - Allied Signal, Inc; ATT - American Telephone & Telegraph; CYP - Cypress Corp; EDI - EDI Corp; FOR - Force, Inc; FUJ - Fujitsu, Ltd; H&R - Harris, Corp; HPA - Hitachi, Ltd; IBM - International Business Machines; IDT - Integrated Device Technology; INT - Intel Corp; ISM - Inmos, Corp; SS - ISS, Inc; MAT - Matsushita; MCN - Micron Technologies; MHS - Matra-Harris Semiconductor (France); MIT - Mitsubishi; MOT - Motorola Semiconductor Products; MPC - Micropac, Corp; NEC - Nippon Electric Corp; NSC - National Semiconductor; PES - Performance Semiconductors; QSI - Quickswitch, Inc; SAM - Samsung, Corp; SNY - Sony Corp; TX - Texas Instruments; TOS - Toshiba; UTM - United Technologies Microelectronics Center;												
Test Houses				Radiation Facilities:								
GSEFC - Goddard Space Flight Center, Greenbelt, MD				BNL - Tandem Van de Graaff, Brookhaven National Laboratories, Long Island, NY								
ESA = European Space Agency, Noordwijk, Netherlands				CYC - CYCLONE, Université Catholique de Louvain-la-Neuve, Belgium								
HON - Honeywell Space Systems, Clearwater, FL				JUCF - Indiana University Cyclotron Facility, Bloomington, IN								
JPL - Jet Propulsion Laboratory, Pasadena, CA				PSI - Paul Scherrer Institute, Villigen, Switzerland								
MMS - Matra Marconi Space, France				SAT - SATURNE, CEA, Saclay, France								
SAB - Ericsson Space AB, Linköping, Sweden				TRI - TRI University Meson Facility, Vancouver, British Columbia, Canada								
SEI - Space Electronics, Inc, San Diego, CA				UCD - University of California at Davis, Crocker Nuclear Laboratory, Davis, CA								
				VEC - Variable Energy Cyclotron AERE, Harwell, UK								

TABLE 3
Proton Displacement Damage Compendium

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Device section (cm ²)	Bit section (μm ²)	Test Date	LJ _{in}	LJ _{xsection} (cm ²)	Frac.	Remarks
		DAC(8-bit)										13-Aug-99
GSFC DAC 08		Bipolar		ADI PNI	58			1997				UDC O'Bryan, et al 98IEEE Workshop Record, pg 39, lii & ref out of spec @ 30 krad.s.
GSFC DAC 08		Bipolar		RAY	59			1997				UDC O'Bryan, et al 98IEEE Workshop Record, pg 39. No parameters out of spec @ 30 krad.s.
		DC/DC Power Converters										
GSFC MHF-2810SS	Single output, +5 V	Hybrid		ITP	51 MeV protons			1997				LLU O'Bryan, et al 98IEEE Workshop Record, pg 39, DIC 9616. Ceased regulating @ 4.4E11 p/cm ² .
GSFC MHF-2810SS	Single output, +5 V	Hybrid		ITP	195 MeV protons			1997				IUCF O'Bryan, et al 98IEEE Workshop Record, pg 39, DIC 9616. Ceased regulating @ 4.4E11 p/cm ² .
GSFC MHF-2812D	3-Output, +5 V, +12 V,	Hybrid		ITP	51 MeV protons			1997				LLU O'Bryan, et al 98IEEE Workshop Record, pg 39, DIC 9613. Ceased regulating @ 4.4E11 p/cm ² .
GSFC MHF-2812D	3-Output, +5 V, +12 V,	Hybrid		ITP	195 MeV protons			1997				IUCF O'Bryan, et al 98IEEE Workshop Record, pg 39, DIC 9613. Ceased regulating @ 4.4E11 p/cm ² .
		Optocouplers										
GSFC 62123	Optocoupler			MPC	58			1997				TRI O'Bryan, et al 98IEEE Workshop Record, pg 39. Shows CTR degradation and some SETs.
GSFC 66088	Optocoupler			MPC	63			1997				UDC O'Bryan, et al 98IEEE Workshop Record, pg 39. No CTR degradation.
GSFC 666999	Optocoupler			MPC	58			1997				TRI O'Bryan, et al 98IEEE Workshop Record, pg 39. *No CTR degradation.
GSFC 4N49	Optocoupler			MPC	58			1997				TRI O'Bryan, et al 98IEEE Workshop Record, pg 39. No CTR degradation.
GSFC 4N49	Optocoupler			MPC	58			1997				TRI O'Bryan, et al 98IEEE Workshop Record, pg 39. No SETs or CTR degradation.
GSFC HCPL-4651	Optocoupler			HPA	220	1.0E-08		1997				TRI O'Bryan, et al 98IEEE Workshop Record, pg 39. No CTR degradation.
GSFC HCPL-4651	Optocoupler			HPA	70	1.0E-07		1997				IUCF O'Bryan, et al 98IEEE Workshop Record, pg 39. No CTR degradation. Cross section @ 90°.
GSFC HCPL-4651	Optocoupler			HPA	58	1.0E-07		1997				TRI O'Bryan, et al 98IEEE Workshop Record, pg 39. No CTR degradation with active or passive filters.
GSFC P2824	Optocoupler			HAM	51.8			1997				LLU O'Bryan, et al 98IEEE Workshop Record, pg 39. CTR degraded below specification with drive current 7.2 mA, @ 6E10 p/cm ² .
GSFC P2824	Optocoupler			HAM	195			1997				IUCF O'Bryan, et al 98IEEE Workshop Record, pg 39. CTR degraded below specification for all drive currents (max. 12.1 mA) @ 1.5E11 p/cm ² .
		Other Linear										
GSFC PF0RX12	Data Transmission Receiver			ONI	62.5			1997				UDC O'Bryan, et al 98IEEE Workshop Record, pg 39. No bit errors up to 30 krad.s. Error bursts at 85 krad.s.
GSFC PFOTX12	Data Transmission Xmit			ONI	62.5			1997				UDC O'Bryan, et al 98IEEE Workshop Record, pg 39. No bit errors up to 30 krad.s. Error bursts at 85 krad.s.
GSFC REF-43	2.5 V Reference	Voltage Reference		Bipolar	ADI var.			1997				var. O'Bryan, et al 98IEEE Workshop Record, pg 39. Vref sensitivity @ 20-30 krad.s.
		Manufacturers: ADA - Advanced Analog Devices, Inc; HAM - Hamamatsu; HPA - Hewlett-Packard; MPC - Micropac Corp; ONI - Optical Networks, Inc; PMI - Precision Monolithic, Inc; RAY - Raytheon										
		Test House:										Radiation Facilities:
		GSFC - Goddard Space Flight Center, Greenbelt, MD										IUCF - Indiana University Cyclotron Facility, Bloomington, IN
												LLU - Loma Linda University Medical Center, Loma Linda, CA
												TRI - TRI-University Mason Facility, Vancouver, British Columbia, Canada
												UCD - University of California at Davis, Crocker Nuclear Laboratory, Davis, CA